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ELECTRIC INSULATION CERAMICS BASED ON RAW MATERIALS FROM UZBEKISTAN

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The possibility of using local materials from Uzbekistan in the production of electrotechnical ceramic is demonstrated. It is established that the optimum mechanical and electrophysical characteristics are registered in samples in which the silica component is to a great extent represented by cristobalite.

Special attention in Uzbekistan is currently paid to the development of the electric engineering industry. The use of local materials is essential in view of the need to lower the production costs as much as possible.

We have investigated the compositions and properties of porcelain mixtures based on known materials and on new types of raw materials from Uzbekistan that have a better quality: Angrenskoe primary concentrated kaolin AKS-30, quartz-sericite rock from the Boinaksaiskoe deposit, and Lyangarskoe quartz sand.

The chemical composition and technological properties of Angrenskoe primary concentrated kaolin shows that it can be used a material for high-voltage porcelain (Table 1). For reference purposes Table 1 lists the chemical composition of one of the best kaolins, the one supplied from the Prosyanosvkoe deposit.

Nevertheless, compared to the Prosyanosvkoe kaolin, Angrenskoe kaolin of grade AKS-30 contains substantial quantities of free quartz, which perceptibly deteriorates its essential technological properties, such as plasticity, sinterability, and mechanical strength of samples. When molding articles from this kaolin, it is necessary to add a plasticizing additive, in our case Druzhkovskoe clay in an amount up to 10% (here and elsewhere mass content indicated). The stony components in mixtures are represented by quartz sand and broken porcelain. The flux in the experimental mixtures was quartz-sericite rock from the Boinaksaiskoe deposit acting as a substitute for potassium feldspar.

It can be seen from Table 1 that by its total content of alkali and alkaline-earth oxides, as well as a $K_2O : Na_2O$ ratio equal to 8.8, this mineral material fully satisfied the requirements imposed on feldspar material for the electrotechnical industry [1]. Its mineralogical composition is represented by sericite $KAl_2[Al_2Si_3O_{10}]OH_2$ and quartz, with the respective contents of 30 – 35 and 55 – 60%. The increased content of quartz compared to its usual content in feldspars and pegmatites makes it possible to replace quartz sand completely or partially when selecting compositions for high-voltage porcelain mixtures.

The stony materials were introduced into experimental mixtures after preliminary crushing and screening of parti-

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TABLE 1

Material	Mass content, %							
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	$K_2O + Na_2O$	calcination loss
Angrenskoe concentrated kaolin:								
primary AKS-30	56.60	0.45	30.10	0.95	0.10	0.10	1.40	10.30
secondary	59.39	0.30	26.70	1.52	0.27	0.40	1.32	10.10
Prosyanosvkoe kaolin	47.50	0.56	36.82	0.70	0.56	0.30	0.82	12.74
Boinaksaiskoe quartz-sericite rock	79.20	0.20	14.30	0.35	0.05	0.26	3.94	1.70
Lyangarskoe quartz sand	96.00	–	1.23	0.17	–	–	0.14	2.18

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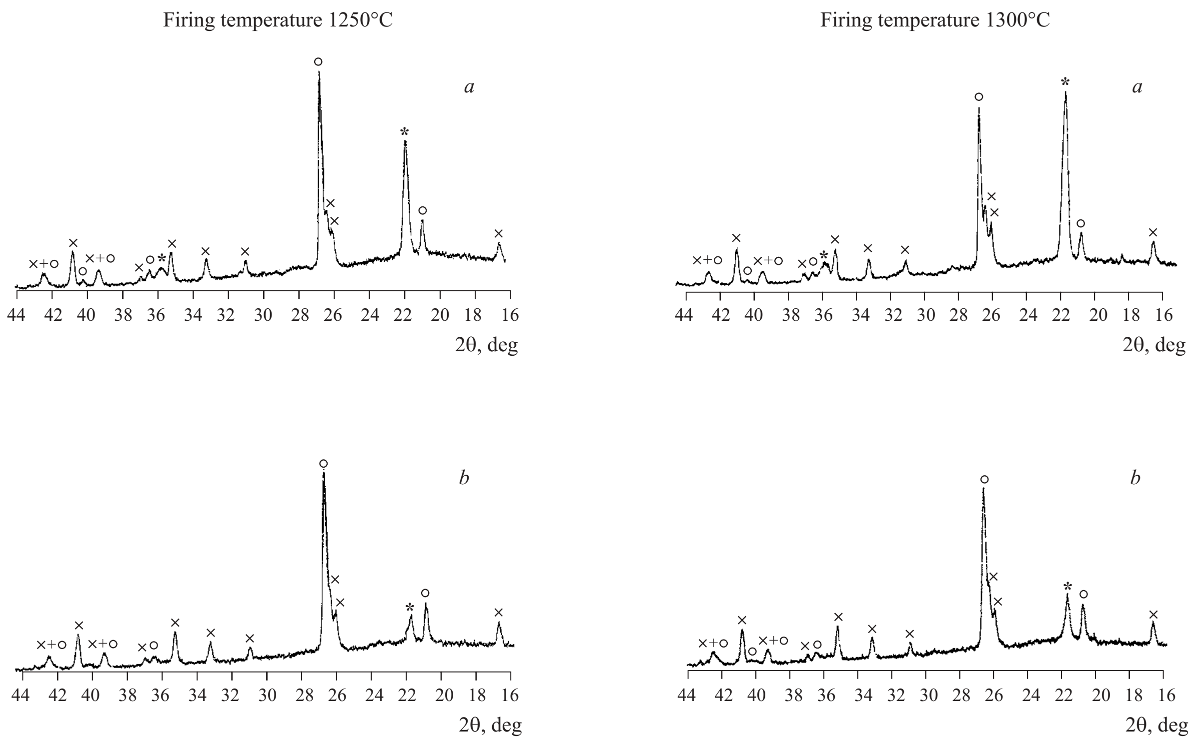

Fig. 1. Diffraction patterns of samples É-1 (*a*) and É-3 (*b*): ×) mullite; ○) α-SiO_2, ∗) cristobalite.

cles of size over 1 mm; next, the mixtures were subjected to joint moist milling in a ball mill up to a residue on a No. 0063 sieve not more than 1%. After dehydration and drying, standard samples were produced by semidry molding (GOST 24409–80) and fired; then their mechanical and electric properties were determined. Table 2 lists the compositions of the experimental mixtures and Table 3 shows the properties of the fired samples.

It can be seen that the replacement of a part of quartz sand by the quartz-sericite rock, which is a good flux, improves sintering and, accordingly, produces more compact ceramics. The presence of Druzhkovskoe clay in the mixture has a similar effect.

To study the phase transformations in firing and determine the relations between the composition and the properties of materials, x-ray phase analysis of the densest sintered samples É-1 and É-3 was carried out. The analysis was performed on a DRON-UM-1 diffractometer (CuK_α radiation, Ni filter). All diffraction patterns of the materials exhibit diffraction maximums belonging to α-quarts, α-cristobalite, and mullite; the highest intensity is registered in the reflections of α-quartz and α-cristobalite, which, taking into account the chemical analysis data, makes it possible to classify these ceramics as high-quartz porcelain. The chemical composition of the optimum mixture is as follows (%): 68.39 SiO_2, 22.40 Al_2O_3, 0.67 Fe_2O_3, 0.35 TiO_2, 0.17 CaO, 0.26 MgO, 2.34 K_2O, 0.19 Na_2O, and 5.23 calcination loss.

However, one should note the difference in the quantitative ratio between the phases present, At a firing temperature of 1250°C the maximum intensity is observed in the reflections of α-quartz, and sample É-3 contains more α-quartz than sample É-1 (Fig. 1). It is established that despite the

TABLE 2

Experimental mixture	Mass content, %*			
	quartz sericite	kaolin AKS-30	Druzhkovskoe clay	quartz sand
É-1	30	40	10	10
É-2	35	40	10	5
É-3	40	40	10	–
É-4	30	45	5	10
É-5	35	40	5	10

* In all mixtures the content of broken porcelain was 10%.

TABLE 3

Experimental mixture	Apparent density, g/cm^3	Open porosity, %	Water absorption, %
	Firing temperatures 1250°C		
É-1	2.42	1.30	0.55
É-2	2.45	0.56	0.23
É-3	2.48	0.40	0.16
É-4	2.29	9.10	3.97
É-5	2.43	2.40	0.80
	Firing temperature 1300°C		
É-1	2.47	0.29	0.12
É-2	2.49	0.52	0.21
É-3	2.49	0.62	0.25
É-4	2.39	3.98	1.66
É-5	2.41	0.88	0.35

TABLE 4

Parameter	Sample É-1 at firing temperature, °C		Sample É-3 at firing temperatures, °C	
	1250	1300	1250	1300
Fire shrinkage, %	9.3	10.4	10.1	9.6
Water absorption, %	0.55	0.12	0.16	0.25
Open porosity, %	1.30	0.29	0.40	0.62
Apparent density, g/cm^3	2.42	2.46	2.48	2.49
Bending strength, MPa	–	110	100	–
Electric strength, kV/mm^2	–	30	20	–
Dielectric permeability	–	6.2	7.4	–
Dielectric loss tangent at 0.3 kHz	–	22×10^{-3}	15×10^{-3}	–

TABLE 5

Frequency, kHz	Dielectric loss tangent, 10^{-3}	Dielectric permeability
	Sample É-1	
0.3	2.30	6.20
1.0	2.20	6.15
3.0	2.10	6.10
10.0	2.00	5.92
	Sample É-3	
0.3	1.45	7.40
1.0	1.30	7.29
3.0	1.20	7.24
10.0	1.10	7.15

complete sintering and high mechanical strength of sample É-3, firing at the specified temperature does not produce materials with high electric characteristics (Table 4).

As for material É-1, its samples produced at the firing temperature of 1250°C do not have sufficiently high mechanical and electrical density and strength due to its incomplete sintering. Increasing the firing temperature to 1300°C leads to an increased content of α-cristobalite and a decreased intensity of α-quartz reflections in all samples. However, in sample É-1 the alpha-cristobalite reflections are the most intense, whereas in sample É-1 α-quartz remains the main silica component. Firing at the specified temperature has made it possible to obtain electroinsulating material of the composition É-1 with good mechanical and electrical characteristics. At the same time, for sample É-3 this firing temperature proved to be excessive, which deteriorated the main properties of this ceramic.

The data obtained confirm the opinion of the authors in [2] that it is possible to successfully combine high mechanical and electric strength in high-quartz materials made of highly dispersed initial components and corroborate the dependence of the electric properties of porcelain on its content of α-cristobalite. Therefore, in selecting an optimum sintering temperatures, it is necessary to take into account the rate of transformation of α-quartz into α-cristobalite depending on the mixture composition, since the presence of cristobalite in electrotechnical porcelain is a significant factor affecting it properties.

The low values of the dielectric loss tangent to a great extent are determined by the low content of Na_2O in the initial material.

Table 5 shows the dependence of the dielectric permeability and the dielectric loss tangent on frequency.

It can be seen that while the general trend of both above parameters is to decrease with increasing frequency, the dielectric loss tangent of sample É-1 retains greater stability in the specified frequency range compared to sample É-3. As frequency grows from 10^2 to 10^4 Hz, the modification in this parameter is 13 and 20 %, respectively.

The obtained results show that traditional and nontraditional concentrated raw materials from Uzbekistan can be used to produce porcelain with high-quality parameters.

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